Effect of Surface Treatment on Liquid Adhesion Inside 3-D Structures

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Introduction

-Adhesion between a tube and liquid increases the drag (friction) during flow

-Adhesion also determines the rise of a liquid in a capillary tube by the function,

$$h = \frac{2\gamma \cos\theta}{\rho g r}$$

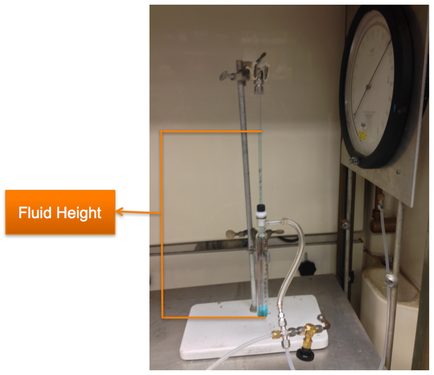
where h is the rise of liquid column in a capillary, γ is the liquid-air surface tension (force/unit length), θ is the contact angle, ρ is the density of liquid (mass/volume), g is local acceleration due to gravity, and r is radius of tube.

$$P_{H20} = \rho g h \rightarrow P_{cap} = \frac{2\gamma \cos\theta}{r}$$

Purpose

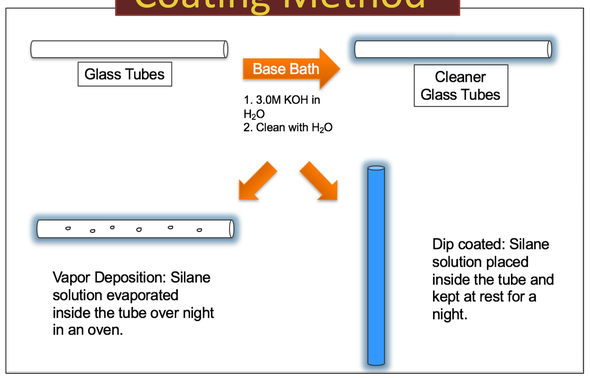
- Evaluate coating methods of surface functionalization using internal probe liquids.
- Explore relationship of surface functionality, and coating methods and probe liquid column height.
- Measure the liquid-tube interaction using an adapted manometer setup.
- Relate measurements to contact angle, coating methods, and quality.

Lab Setup

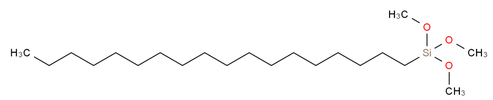


Experimental

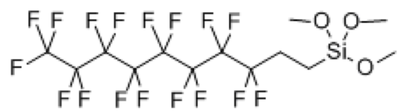
Coating Method[1]



Silanization

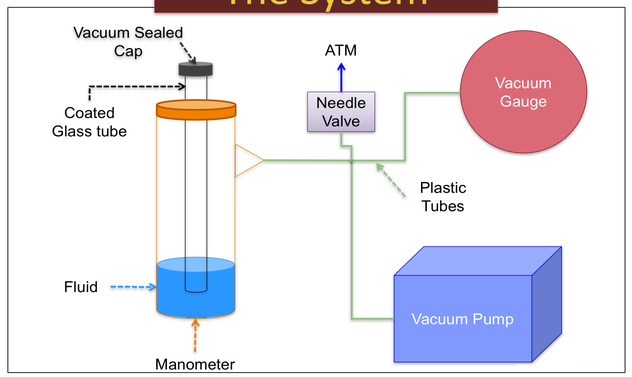


Trimethoxy (octadecyl) silane in Heptane

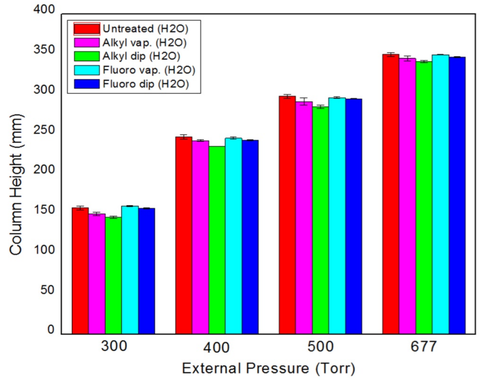


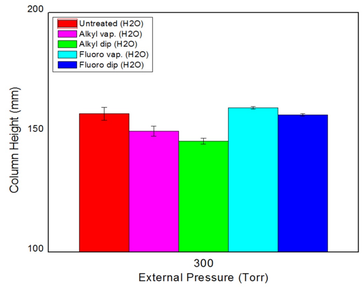
(Heptadecafluoro-1,1,2,2-tetrahydrodecyl)trimethoxysilane in Toluene

The System

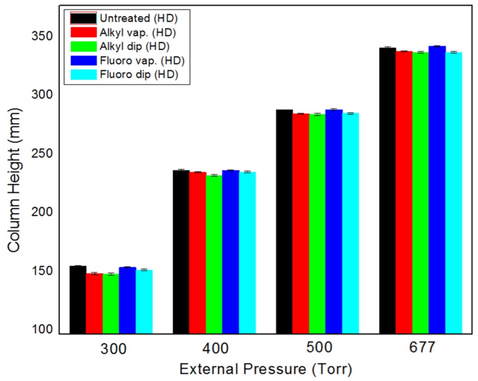


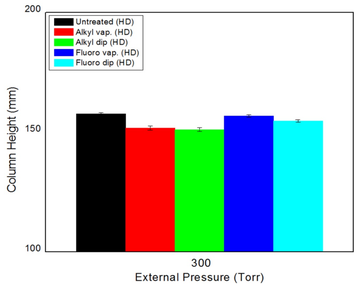
H_2O





n-Hexadecane





Contact Angles

Water

	Meas. Contact Angles		Eq. Angle	Calculated Capillary Height			Measured Δh	
Treatment	**θa**	**θr**	**θc**	**Δha**	**Δhr**	**Δhc**	**Δh**	**stdev**
Untreated	40	4	22	0.0	0.0	0.0	0.0	2.6
Alkyl (dip)	110	70	87	-8.2	-4.9	-6.4	-11.2	1.4
Alkyl (vapor)	87	49	67	-5.3	-2.6	-3.9	-5.8	1.9
Fluoro (dip)	108	75	89	-8.0	-5.4	-6.7	-2.7	1.3
Fluoro (vapor)	103	22	56	-7.4	-0.5	-2.7	-0.2	1.4

Hexadecane

	Meas. Contact Angles		Eq. Angle	Calculated Capillary Height			Measured Δh	
Treatment	**θa**	**θr**	**θc**	**Δha**	**Δhr**	**Δhc**	**Δh**	**stdev**
Untreated	5	0	2	0.0	0.0	0.0	0.0	0.7
Alkyl (dip)	30	0	8	-0.5	0.0	0.0	-4.6	0.5
Alkyl (vapor)	10	0	3	0.0	0.0	0.0	-3.5	0.5
Fluoro (dip)	57	0	12	-1.7	0.0	-0.1	-2.8	0.5
Fluoro (vapor)	75	0	15	-2.7	0.0	-0.1	0.2	0.4

Conclusion

-The coating processes tested in the study produced the optimum result with alkyl-dip method.

-Fluorinated samples coating process was not appropriate.

-Column height measurements seem to be a viable method for probing surface treatments for 3D structures.

Future Work

-Measure Roughness

-Try different types of substrates/materials

-Fluorinated liquid infused surfaces

-Amine functionalized silanes (for hydrophilic surface)

-Back pressure testing

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